Adaptive Automata for Syntax Learning

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Abstract. This article presents adaptive automata as an alternative theoretical model to formally describe recognizing devices with learning capabilities. A simplified formal definition of the notation and its semantics is given, and some analysis is made on their time and space behavioral properties, showing positive aspects that make them suitable for knowledge acquisition and for describing and processing natural languages. A simple application of adaptive automata in this field is then shown, illustrating how they may be employed in the construction of a little sample-driven syntax-learning device for regular languages. The paper concludes that adaptive automata are well-suited not only to describe context-dependent languages and to operate as a powerful learning formalism, but also as very convenient formal specification tool to describe and even automate efficient implementations too.

Keywords: adaptive automata, syntax learning, knowledge acquisition.

Introduction

Syntax Learning is a task that may be automatically performed in a number of ways. This paper is concerned with syntax learning within adaptive automata. Adaptive automata are Turing-powerful formal devices intended to describe context-dependent languages, which operate on finite-state or pushdown automata while accepting already-known syntax.

Once some not yet explored legal aspect of the syntax is detected in the input string, a corresponding so-called adaptive action is taken. The purpose of that action is to modify the automaton to accept further instances of the new syntax. Besides of adapting itself to follow the syntactical needs of the input string, adaptive automata may be added further self-modifications. Those changes may be designed to enable the automaton to retain information on the already acceptable set of sentences, so implementing the basics for acquiring knowledge about its input language. In extreme cases, an initial all-accepting automaton may evolve by steps, during a learning phase, into a tree-shaped automaton that strictly accepts the set of already read sentences.

In a second turn, small generalization procedures may easily convert this acceptor into a graph-shaped automaton describing a wider superset of the language represented by the sample employed to build the former tree. This procedure may lead a automata that accept a syntax wider than needed.

If specializing procedures must be applied to the automaton in order to exclude undesired syntax forms. Obtaining the desired adaptive acceptor may be accomplished in a final specializing phase of the learning process, with the aid of an input sample of rejecting strings. Obviously, the accuracy of the accepting device obtained in this way is highly dependent on the quality of the given samples and on the heuristics adopted in the generalizing and specializing learning procedures. This subject is not covered in this paper for being beyond its scope.

Formal adaptive devices have been presented in many papers as powerful tools for rigorously defining complex languages (Ru95, Fe94, Fu93). Adaptive automata are one of such devices, and their main features include:

- a significant part of the accepting procedure performed by an adaptive automaton is done very efficiently, due to their structure based on finite-state or structured pushdown automata
- a unique feature of adaptive devices is the natural way they may be designed to learn how to handle new syntactic constructs
- adaptive automata are Turing-powerful, allowing them to handle context dependencies in a strict syntactical way, without the aid of auxiliary semantic procedures